

Redescription of *Canthocamptus mirabilis* Štěřba (Copepoda, Harpacticoida), Based on the Topotypic Material from China

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ABSTRACT

Canthocamptus mirabilis Štěřba is redescribed on the basis of the material newly collected from the type locality near Beijing, China, with an evaluation of the variability of several characters. *C. mirabilis* possesses the plesiomorphic characters of the round and narrow hyaline membrane and the unmodified outer terminal furcal setae, while it also bears the apomorphic ones of the male-type caudal rami in females and the modified outer terminal setae of male leg 4 exopod. The peculiar dorsal keel ornamented with spinule array on the female's caudal rami is the most significant feature differentiating this species from its relatives of the *mirabilis* group, which turned out to be a species group of closely related and largely allopatric or parapatric species. Affinities with the allies of the species group are discussed, and the morphological discrepancies differentiating the Japanese population are enumerated.

Key words: Redescription, *Canthocamptus mirabilis*, freshwater, Canthocamptidae, Harpacticoida, Copepoda, China

INTRODUCTION

Canthocamptus mirabilis was described from a streamlet near Beijing, China based on the only three females by Štěřba (1968). As the original description was so poorly prepared, especially with

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the deficiency of male characters, Ito and Takashio (1980) redescribed it on the basis of the materials from Hokkaido, Japan, and first noticed it as "*Atthyella*-like *Canthocamptus*" possessing its own intermediate features between the two genera. Thereafter, throughout the serial faunistic studies on mountainous harpacticoids in Japan (Ishida, 1987, 1989, 1990, 1991; Kikuchi and Ishida, 1988), this peculiar *Canthocamptus* turned out to be a species group of closely related and largely allopatric or parapatric species, to be called as the *mirabilis* group (Kikuchi and Ishida, 1994). Six species are currently recognized in this species group: *C. mirabilis* Štěrba, 1968 from China, *C. morimotoi* Miura, 1969 from South Korea, *C. prominulus* Kikuchi, 1993, *C. semicirculus* Kikuchi, 1993, *C. resupinatus* Ishida, 1993, and *C. tomikoeae* Ishida, 1993 from Japan, which have been known from the various mountain water bodies of the Far East with the great abundance and frequent occurrences (cf. Chang, 1998).

In Korea, after Miura (1969) recorded *Canthocamptus morimotoi*, which was redescribed by me treating the characters of *mirabilis* group with a brief review of the group in East Asia (Chang, 1998), the additional official report on this group has not been made, in spite of the accumulation of specimens belonging to several species of *C. mirabilis* group. The exact taxonomic position and relationships of these species cannot be settled down until the true identity of *C. mirabilis*, the stem species of this group, should be manifested in detail with reference to types or topotypic material, for it is doubtful whether the '*C. mirabilis*' currently recognized in Japan would be identical with *C. mirabilis* Štěrba from China.

In this paper, I deal with the redescription of *C. mirabilis* based upon the new material from the type locality, together with the discussion on the morphological differences between those two populations from China and Japan.

MATERIALS AND METHODS

Collections were made with a dipnet of no. 10 mesh aperture from the washings of fallen leaves, mosses, and bottom sands of a trickle at Lonqingsha Valley, about 110 km northwest of Beijing, China on November 3, 1999. The Japanese specimens which have been identified in the name of *C. mirabilis* were also reexamined. The Japanese specimens examined are: 3 ♀♀, 5 ♂♂, spring and streamlet, Yoichi, Hokkaido, April 28, 1993, T. Ishida; 5 ♀♀, 8 ♂♂, Umekawa Stream, Yoichi, Hokkaido, April 29, 1995, T. Ishida; 2 ♀♀, 2 ♂♂, mangrove flat, mouth of Hinaigawa River, Irimote I., Okinawa, April 16, 1999, T. Ishida.

All the specimens were dissected, drawn, and measured in lactophenol on the Cobb's hole slide. Figures were supplied with the aid of a camera lucida.

The SEM material was prefixed overnight at 4°C in 2.5% glutaraldehyde, then followed by postfixation with 1% cold osmium tetroxide. After dehydration through a graded series of ethanol (50-100% at 10% intervals) for 30 minutes each, the materials were critical point dried, coated with gold-palladium in a high evaporator, and then examined in a Hitachi S-520 scanning electron microscope operated at 20 KV.

Type specimens are not remained, so neotype newly collected from the type locality is established. Neotype is deposited in the Natural History Museum of Ewha Womans University.

Abbreviations used in the description: enp 1-3 or exp 1-3 indicate the first to third endopodal or exopodal segment of each leg; Fn refers to the normal caudal (furcal) ramus and Fr to the male-type caudal ramus of female.

REDESCRIPTION

Family Canthocamptidae Sars, 1906

Subfamily Canthocamptinae Chappuis, 1929

Genus *Canthocamptus* Westwood, 1836

***Canthocamptus mirabilis* Štěrba, 1968 (Figs. 1-4)**

Canthocamptus mirabilis Štěrba, 1968, p. 52, figs. 12-16; Tai and Song, 1979, p. 216, fig. 115.

Attheyella (*Mrazekiella*) *amurensis*: Shen and Sung, 1973, p. 39, figs. 13-24; Tai and Song, 1979, p. 244, fig. 134-135.

Material examined. 34 ♀♀, 25 ♂♂, a trickle at Longingsha Valley, about 110 km northwest from Beijing, China, Nov. 3, 1999, C. Y. Chang. An undissected male is designated as neotype, and deposited in the Natural History Museum, Ewha Womans University under registration number EWNHM60260, with three females and two males. Other specimens are deposited in the collection of the author.

Female. Body (Fig. 1A) ranging 0.65-0.70 mm (0.68 ± 0.03 mm, N=9), excluding rostrum and caudal setae; broadest at posterior margin of cephalothorax, tapering behind. Cephalothorax somewhat protruding anteriorly, a little longer than succeeding 3 thoracic somites combined. Rostrum not prominent, pointed anteroventrally, not defined at its base. Dorsal and lateral surfaces of thoracic somites sparsely haired; posterior part of cephalothorax bearing a thin hyaline membrane with 10-12 longitudinal folds along its margin, each bearing a setule at its tip. Genital double somite moderately expanded laterally and slightly broad posteriorly, 1.35 times wider than long, subdivided by paired lateral suture. Each abdominal somite furnished with a row of spinules along laterodistal corner, and hyaline fringes with crenate posterior margin.

Anal operculum (Fig. 1B, D) convex; hyaline membrane narrow and round along the margin of operculum. Anal segment (Fig. 1B-D) bearing paired spinule array each with 6-7 short spinules at distomedial corner, issuing from ventral surface; spinules relatively short and slender compared with those of the relatives.

Caudal ramus of normal type (Fn) (Fig. 1B) shown as rather suboval, about 1.4 times as long as wide, bearing 2 rows of slender setules with crescentic arrangement along medial face. Dorsal keel running obliquely, anterior to dorsal seta, well-developed and armed with sharp spinules. About 7-8 stout spinules at the laterodistal corner of dorsal surface. Distal part of ventral surface (Fig. 1C) smooth without any particular ornamentation. Outer caudal seta armed with 2-3 pairs of sharp secondary setules, pointing outwardly and situated from proximal one fifth to third; terminal seta stout, little bent and not constricted nor swollen near base; inner caudal seta bare.

Caudal ramus of male type (Fr) slender and shaped as reversed bottle (Fig. 1D). Setule array on medial face usually much weaker than that of Fn's, and often lacking (at times even showing the

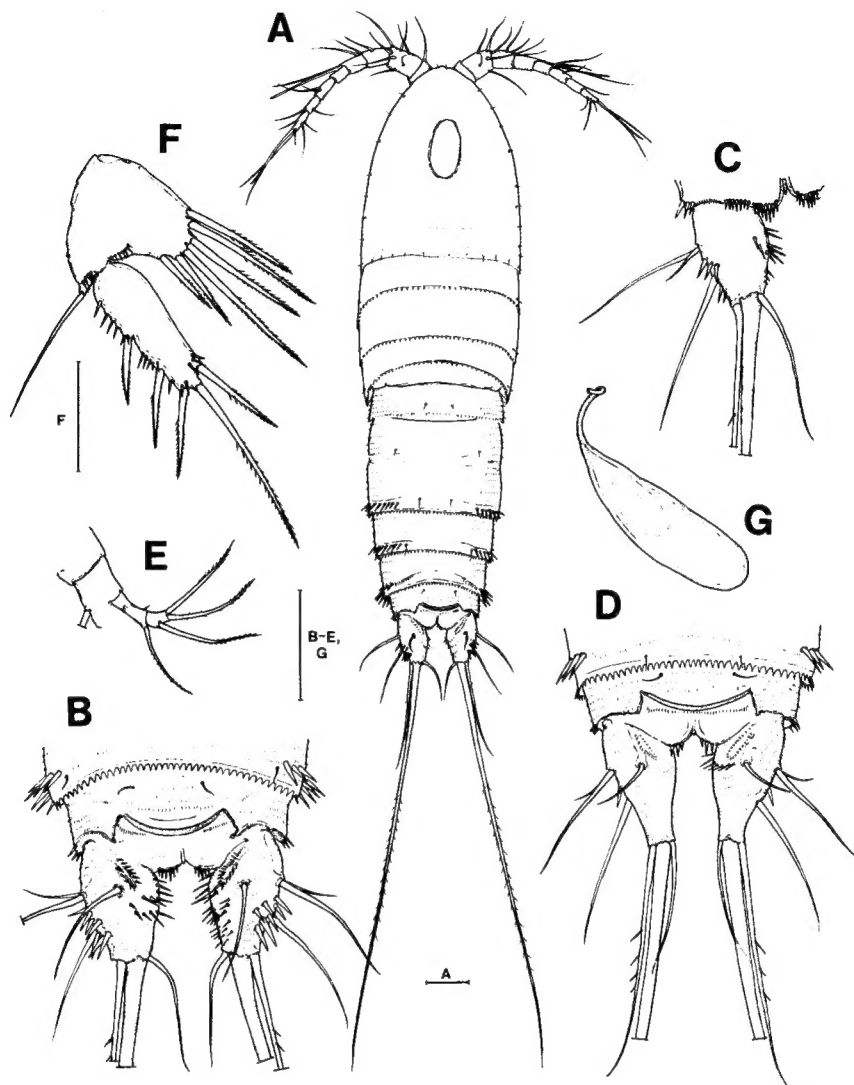


Fig. 1. *Canthocamptus mirabilis* Štěrba, Female. A, Habitus, dorsal; B, Anal segment and caudal rami, dorsal (Fn type); C, Caudal rami, ventral (Fn type); D, Anal segment and caudal rami, dorsal (Fr type); E, Exopod of antenna; F, leg 5; G, Spermatophore. Scale bars = 0.05 mm.

asymmetrical arrangement in an individual as in Fig. 1D). Dorsal keels ornamented with weaker spinules than those of Fn's, or sometimes even lacking them. Laterodistal corner of dorsal surface smooth without any spinule array. Terminal setae similar to those of Fn's.

Antennule of 8 segments, bearing 1 aesthetasc on anterodistal margin of fourth article, its tip not reaching distal end of antennule; tip of last segment also furnished with 1 thin aesthetasc. Exopod of antenna (Fig. 1E) 2-segmented, but sometimes the segmentation shown as indistinct; proximal segment markedly slender, bearing 1 plumose seta on inner distal edge with 1 spinule on laterodistal margin; distal segment bearing 3 plumose setae. Mandible, maxillule, maxilla, and

maxilliped with typical characteristics of genus *Canthocamptus* and showing no significant difference from those of related members of *mirabilis* group (cf. Ito and Takashio, 1980; Chang, 1998).

Exopod and endopod of legs 1–4 each consisting of 3 segments, except endopod of leg 4 with 2 segments. Leg 1 enp 1 as long as exopod, with 1 plumose seta on distal fifth of inner margin; enp 2 with 1 plumose seta on inner distal corner and 3–4 sharp spinules on outer edge; enp 3 slender, bearing 2 geniculate spines and 1 plumose seta. Exp 1 slightly longer than next two segments; exp 2 with 1 inner seta; exp 3 bearing 2 outer and 2 distal geniculate spines. Distal edge of intercoxal sclerites of legs 2–4 with several spinules. Ornamentation of legs 2–4 as follows (in armature formula, Roman numerals indicate spines and Arabic numerals represent setae):

Leg 2	basis I-0	exp I-0; I-1, III, 2, 1 enp 0-1; 0-1; I, 2, 2
Leg 3	basis 1-0	exp I-0, I-1, III, 2, 2 enp 0-1, 0-1, I, 2, 2
Leg 4	basis 1-0	exp I-0, I-1, III, 2, 2 enp 0-1, I, 2, 2

Distal end of leg 5 baseoendopod (Fig. 1F) not reaching a third of exopod; baseoendopod not confluent at its base, connected by intercoxal sclerite; inner margin bare; distal margin near inner proximal edge of exopod with 6–7 spinules; bearing 6 spiniform setae, of which outermost two setae shortest, while fourth seta from inner margin longest. Exopod much elongated, about 3.1 times as long as broad, tapering distally; inner margin bare and nearly straight; armed with 5 ‘awn-type’ setae, distalmost seta much longer (1.3 times) than exopod; 2–3 spinules usually present on distomedial corner of ventral side near base of inner seta.

Spermatophore (Fig. 1G) about 3.3 times as long as broad; distal margin a little convex and blunt; stalk rather long and twisted at its basal part.

Male. Body (Fig. 2A) length ranging 0.62–0.67 mm (0.64 ± 0.03 mm, $N = 11$). Overall appearance much as female, except with slenderer caudal rami. Hyaline membrane on anal operculum (Fig. 2A) round and convex, generally well-developed as compared with female’s, but its tip not reaching level of dorsal seta. Anal segment bearing paired spinule array each with 6–7 short spinules at distomedial corner of ventral surface, of which innermost two conspicuous and relatively a little longer than those of females. Medial face of caudal rami always bare; dorsal keel of caudal rami lacking spinule rows; laterodistal corner of dorsal surface smooth without spinules.

Leg 2 (Fig. 3A), enp 1 with 1 inner seta; enp 2 bearing 3 inner, 2 long distal setae, with outer spinules; two proximal inner setae of enp 2 and inner seta of exp 3 modified; laterodistal edge of intercoxal sclerites with several sharp spinules. Leg 3 (Fig. 3B), enp 2 armed with 1 acute spine on distomedial edge and 1 terminally barbed process (apophysis), not extending beyond exp 3; enp 3 elongated, a little longer than combined lengths of two preceding segments, tapering distally, ending with 2 plumose setae; exp 2 armed with 1 stout spinous process on outer distal corner, its tip usually not reaching or rarely beyond distal end of exp 3 slightly; exp 3 armed with 2 inner plumose setae, of which distal one strongly modified. Leg 4 (Fig. 3C) nearly same shape as that of female, except outer terminal seta of exp 3 modified and armed with 3–4 stout spinules and 1

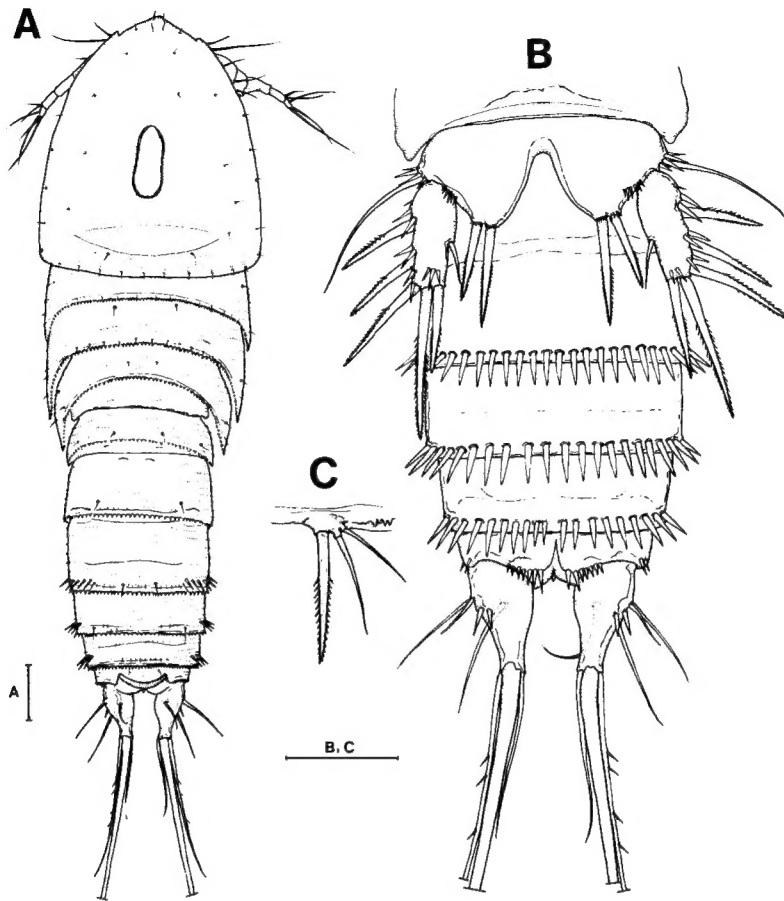


Fig. 2. *Canthocamptus mirabilis* Štěrba, Male. A, Habitus, dorsal; B, Urosome, ventral; C, Leg 6. Scale bars = 0.05 mm.

small spinule; distal part of proximal inner seta of enp 2 and distal inner seta of exp 3 modified.

Baseoendopodal lobe of leg 5 (Fig. 2B) triangular, not reaching middle of exopod; bearing 2 spiniform setae, inner seta about 1.3 times longer than outer; inner margin bare; distal margin near inner proximal edge of exopod with 5-6 spinules as in female. Exopod 2.1 times longer than broad, armed with 6 setae in total, consisting of 1 weak plumose seta at about middle of medial margin, 2 distal, and 3 outer setae. Leg 6 (Fig. 2C) represented by small plate bearing 1 stout spine and 2 slender setae.

Variability. Females with normal-type caudal rami (Fn) were rather occasional (less than 25% of all female specimens examined); Fn always possessed the setule array on the medial face of caudal rami, while 28% of Fr (male-type caudal ramus) were bare, as were the caudal rami of all males. The other Fr had usually weak or sometimes meager setules on one caudal ramus and absent on the other (Fig. 1D). The spinule armature of the dorsal keel of caudal rami were conspicuous in all Fn without exception, while in more than 70% of Fr and all males those were entirely absent. The

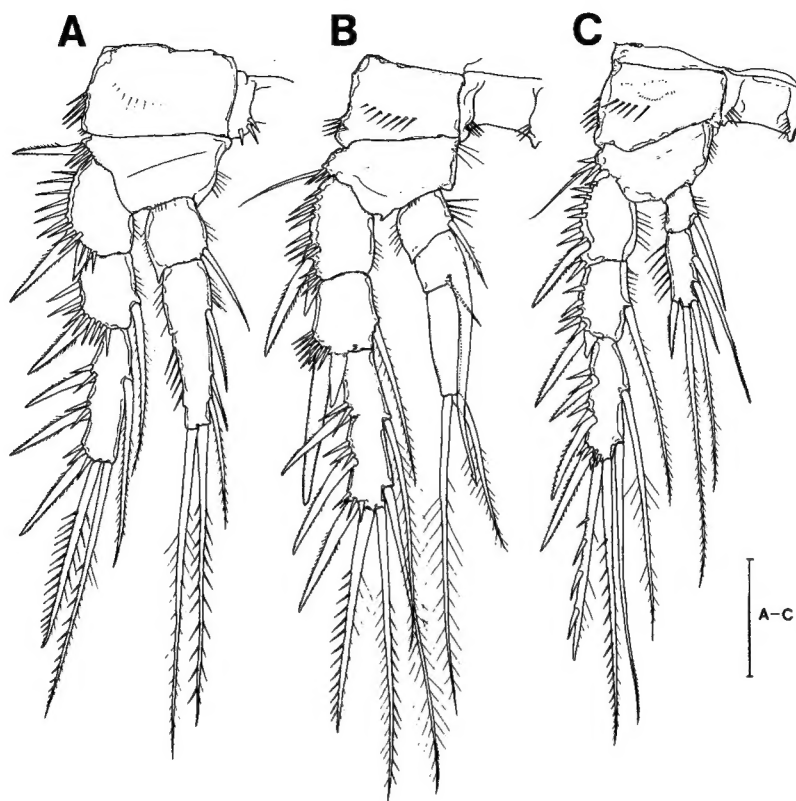


Fig. 3. *Canthocamptus mirabilis* Štěrba, Male. A-C, Legs 2-4. Scale bar = 0.05 mm.

spinule arrangement on the outer distal corner was absent in Fr, and sometimes absent also in Fn; females rarely possessed both the different types of ornamentation. Usually (in more than 95% of cases) the spinous process on the outer distal edge of male leg 3 exp 2 did not exceed the tip of leg 3 exp 3. More than 95% of specimens examined had 2-3 spinules on the inner distal edge of the ventral surface of female leg 5 exopod. In the size arrangement of the setae on female leg 5 baseoendopod, the inner fourth seta is usually the longest, while rarely was found the inner second as the longest. Hardly were found the male individuals possessing three spiniform setae on leg 5 baseoendopod.

No significant variation was observed in the ornamentation of outer terminal caudal seta of both females and males, which were consistently furnished with 3-4 pairs of sharp and slender secondary setules pointing outward. All individuals examined unexceptionally had their typical spinule array on the distal margin of leg 5 baseoendopod near the inner proximal edge of exopod. Not observed were the females carrying the caudal terminal seta swollen at its base. All female specimens examined showed the 'awn-type' setae on the leg 5 exopod. No particular difference was detected in the major ornamentation of legs 2-4.

Remarks. When Štěrba (1968) described *Canthocamptus mirabilis*, he did not manifest the precise locality and only recorded it as a mountain streamlet located at about 100 km northwest of

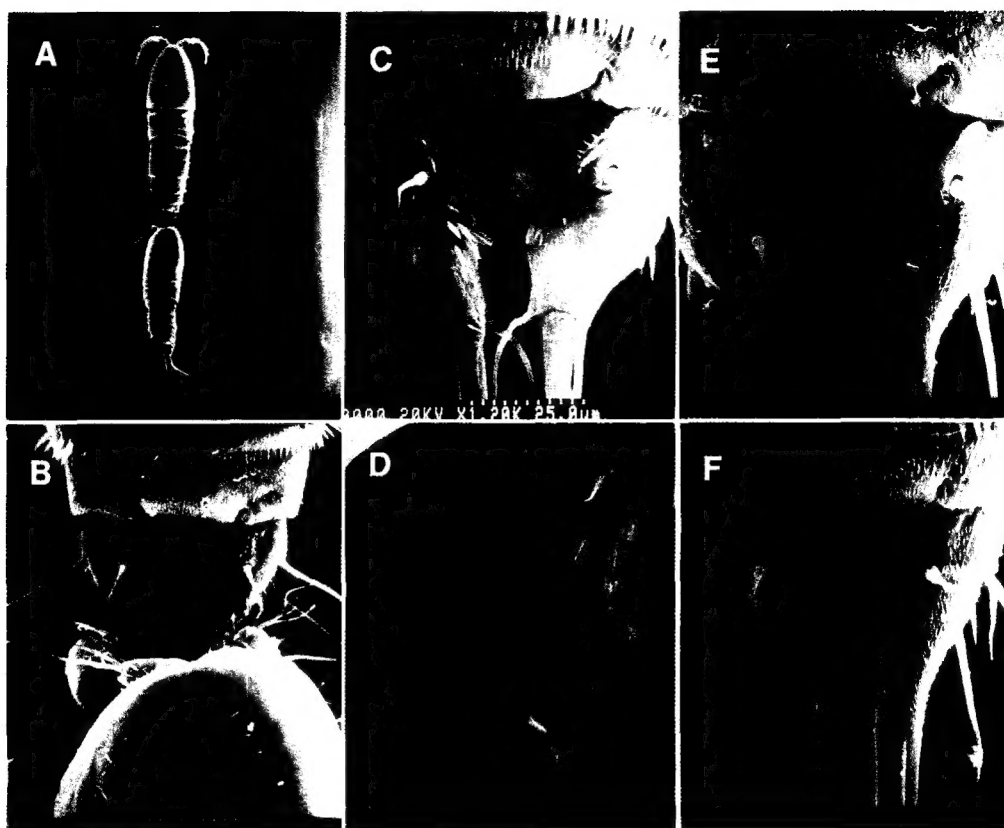


Fig. 4. *Canthocamptus mirabilis* Štěrba. A, A couple in mating; B, Part of Fig. 4A; C, Anal segment and caudal rami, dorsal (Fn type); D, Keel with spinules over dorsal seta of caudal ramus; E, Anal segment and caudal rami, dorsal (Fr type); F, Anal segment and caudal rami, dorsal (male).

Beijing, China. I suppose with modest assurance that the type locality should be the Longqingshao Valley, where the present material was obtained, because this valley is the famous resort place with beautiful scenery, maybe the only region around there over the Great Wall opened to foreigners at that time still in the 'bamboo curtain' era.

The Japanese '*C. mirabilis*', which was fully redescribed by Ito and Takashio (1980) on the basis of the specimens from Hokkaido, is now known to be distributed around Hokkaido, northern Honshu (Iwate Pref. and Niigata Pref.) and Irimote I. of Okinawa Pref. (Ishida and Kikuchi, 2000). As far as I examined, the Japanese specimens from Hokkaido and Okinawa nearly coincided with each other. However, it is quite doubted whether Japanese ones would be identical with the type specimens of Štěrba (1968) from China. The present topotype of *C. mirabilis* shows lots of morphological discrepancies from the redescription of Ito and Takashio (1980) and the Japanese specimens examined by the author himself by the characteristics as follows: (1) much smaller body size (less than 0.7 mm against largely over 1.0 mm in Japanese ones); (2) the possession of strong dorsal keel with the spinule array along margins in the normal type of female caudal rami (Fig. 1B,

4C), (3) always lacking the medial setules of caudal rami in males, (4) lacking spinules around the inner distal corner of ventral side of Fn (Fig. 1C), while somewhat conspicuous ventral spinules present in Japanese ones (cf. Ito and Takashio, 1980, Fig. 2B), (5) the outer terminal caudal setae ornamented with a few much feeble secondary setules, (6) on the distomedial corner of anal segment, the weaker and smaller spines conspicuously contrasting with those of Japanese specimens, especially in the case of the innermost two of female's, (7) the much elongated exopod of female leg 5 with the straight medial margin and very long terminal seta, (8) the presence of typical spinule array on the ventrodistal margin of leg 5 baseoendopod near the inner proximal edge of exopod in both sexes, and the additional two minor discrepancies with some variability: (9) the size arrangement of setae on female leg 5 baseoendopod (the inner fourth seta is usually longest while the inner second one longest in Japanese specimens), (10) the long spinous process on male leg 3 exopod 2 nearly reaching the tip of exopod 3 against the Japanese ones usually exceeding it. The character differences as mentioned above strongly suggest that Japanese one should be recognized as another distinct species different from *C. mirabilis* Štěřba.

The '*Attheyella* (*Mrazekiella*) *amurensis*' reported from Kirin, Manchuria by Shen and Sung (1973), which was regarded as *C. mirabilis* by Ito and Takashio (1980), is fitted well with the specimens from Beijing in sharing the convex anal operculum without hyaline membrane, the subconical caudal rami with normally feathered outer caudal seta and well-developed dorsal keel, and the female leg 5 exopod not furnished with setules on the medial edge. However, whether the '*A. amurensis*' sensu Shen and Sung is identical with the types of *A. amurensis* Borutzky, 1936 or not cannot be confirmed at present, for the original description was so poorly prepared without any manifestation of the *mirabilis*-group's characters and it was made on the basis of male specimens only. But it is rather probable for them to be identical each other in consideration of a few features of the group shown in his figures like the elongate spinous process of male leg 3 exopod and the general shape of male leg 5 and caudal rami (see Borutzky, 1936). If so, Borutzky has the priority and this species must be designated as "*Canthocamptus amurensis* (Borutzky, 1936)". However, for the time being, the name of "*C. mirabilis*" would be used provisionally until the identity is confirmed, and *Attheyella amurensis* Borutzky, 1936 is remained as a *species inquirendae*.

Considering the posture of copulation as shown in Fig. 4A and 4B, especially in the *mirabilis* species group consisting of closely related and largely allopatric or parapatric species, undoubtedly are significantly meaningful for the reproductive isolation the shape of anal operculum with hyaline membrane and caudal rami as the pre-mating markers for perceiving their own couples, as well as the ornamentation of outer terminal setae as the coupling device. *C. mirabilis* possesses the seemingly plesiomorphic characters of the round and narrow hyaline membrane and the somewhat plain and non-diversified outer terminal caudal setae as *C. semicirculus* and *C. tomikoeae*, while it shares the apomorphic ones of the male-type caudal rami in females and the modified outer terminal setae of male leg 4 exopod with *C. prominulus* Kikuchi and *C. resupinatus* Ishida. *C. mirabilis* distinctly differs from *C. morimotoi* Miura from South Korea in the general shape of caudal rami with the outer terminal caudal setae, the round hyaline membrane of anal operculum, and the modified outer terminal setae of male leg 5 exopod 3. The peculiar dorsal keel on the female caudal rami ornamented with spinule array is the most significant feature differentiating this

species from its relatives of the *mirabilis*-group.

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중국의 모식산지에서 채집한 갈고리노벌레류
Canthocamptus mirabilis Štěrba의 재기재

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요 약

동아시아의 계류와 하천에 우점적으로 서식하는 딱정장수노벌레속 *Canthocamptus* (요각아강, 갈고리노벌레목)의 *mirabilis* 종군은 *Attheyella* 속과의 중간 형질을 나타내는 특이한 분류군으로서, 이소적 또는 축소적으로 매우 빠르고 다양하게 종분화한 것으로 최근 연구되고 있다. 그러나, 대표종이라 할 수 있는 *C. mirabilis* Štěrba가 매우 불완전하게, 그것도 암컷만으로 기재되었고 모식이 남아 있지 않아서 이 종군의 분류에 많은 지장과 혼란이 있어 왔다. 저자는 중국 북경 근교의 모식산지에서 새롭게 채집한 표본을 근거로 재기재를 하였고, 이를 통해 앞서 일본산 표본을 근거로 하여 작성되었던 과거의 재기재와의 차이점을 열거함으로써 일본산 표본들은 별개의 종임을 제시하였다. 아울러 본 종군에 속하는 여타 종과의 형태적 차이와 유연관계에 대하여서도 간략히 고찰하였다.